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INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference ECIP/E009/W0	FOR FURTHER ACTION see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
International application No. PCT/IL 01/00063	International filing date (day/month/year) 23/01/2001	(Earliest) Priority Date (day/month/year) 25/01/2000
Applicant LIGHTSCAPE NETWORKS LTD.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.

☒ It is also accompanied by a copy of each prior art document cited in this report.

1. Basis of the report

- a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

☐ the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

- b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing:

☐ contained in the international application in written form.

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☐ the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

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2. ☐ **Certain claims were found unsearchable** (See Box I).

3. ☐ **Unity of invention is lacking** (see Box II).

4. With regard to the **title**,

☒ the text is approved as submitted by the applicant.

☐ the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,

☒ the text is approved as submitted by the applicant.

☐ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No.

☒ as suggested by the applicant.

☐ because the applicant failed to suggest a figure.

☐ because this figure better characterizes the invention.

5

☐ None of the figures.

INTERNATIONAL SEARCH REPORT

International Application No

PCT/IL 01/00063

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 H04L12/56 H04Q11/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EP0-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 488 501 A (BARNSLEY PETER E) 30 January 1996 (1996-01-30)	1-5, 11, 12, 18-20, 27-30, 35-43
A	figures 1,6,7	6-10, 13-17, 21-26, 31-34
A	US 5 541 756 A (CHANG-HASNAIN CONSTANCE J ET AL) 30 July 1996 (1996-07-30) figures 1-4	1-43
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☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

A document defining the general state of the art which is not considered to be of particular relevance

E earlier document but published on or after the international filing date

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O document referring to an oral disclosure, use, exhibition or other means

P document published prior to the international filing date but later than the priority date claimed

T later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

X document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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Z document member of the same patent family

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	<p>JEONG G ET AL: "COMPARISON OF WAVELENGTH-INTERCHANGING AND WAVELENGTH-SELECTIVE CROSS-CONNECTS IN MULTIWAVELENGTH ALL-OPTICAL NETWORKS" PROCEEDINGS OF INFOCOM,US,LOS ALAMITOS, IEEE COMP. SOC. PRESS, vol. CONF. 15, 24 March 1996 (1996-03-24), pages 156-163, XP000622306 ISBN: 0-8186-7293-5 figure 3</p> <p>----</p>	1-43
A	<p>HUI J Y: "PATTERN CODE MODULATION AND OPTICAL DECODING - A NOVEL CODE-DIVISION MULTIPLEXING TECHNIQUE FOR MULTIFIBER NETWORKS" IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS,US,IEEE INC. NEW YORK, vol. 3, no. 6, 1 November 1985 (1985-11-01), pages 916-927, XP000606948 ISSN: 0733-8716 figure 1</p> <p>----</p>	1-43
A	<p>US 5 617 233 A (BONCEK RAYMOND K) 1 April 1997 (1997-04-01) cited in the application the whole document</p> <p>----</p>	1-43
A	<p>US 5 253 250 A (EICHEN ELLIOT ET AL) 12 October 1993 (1993-10-12) cited in the application the whole document</p> <p>-----</p>	1-43

INTERNATIONAL SEARCH REPORT

Information on patent family members

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5488501 A	30-01-1996	AU 3901093 A CA 2123220 A,C DE 69323189 D DE 69323189 T EP 0635180 A ES 2127272 T WO 9321706 A SG 48849 A JP 7507188 T	18-11-1993 28-10-1993 04-03-1999 09-09-1999 25-01-1995 16-04-1999 28-10-1993 18-05-1998 03-08-1995
US 5541756 A	30-07-1996	NONE	
US 5617233 A	01-04-1997	NONE	
US 5253250 A	12-10-1993	CA 2085395 A EP 0550046 A JP 5268268 A	01-07-1993 07-07-1993 15-10-1993

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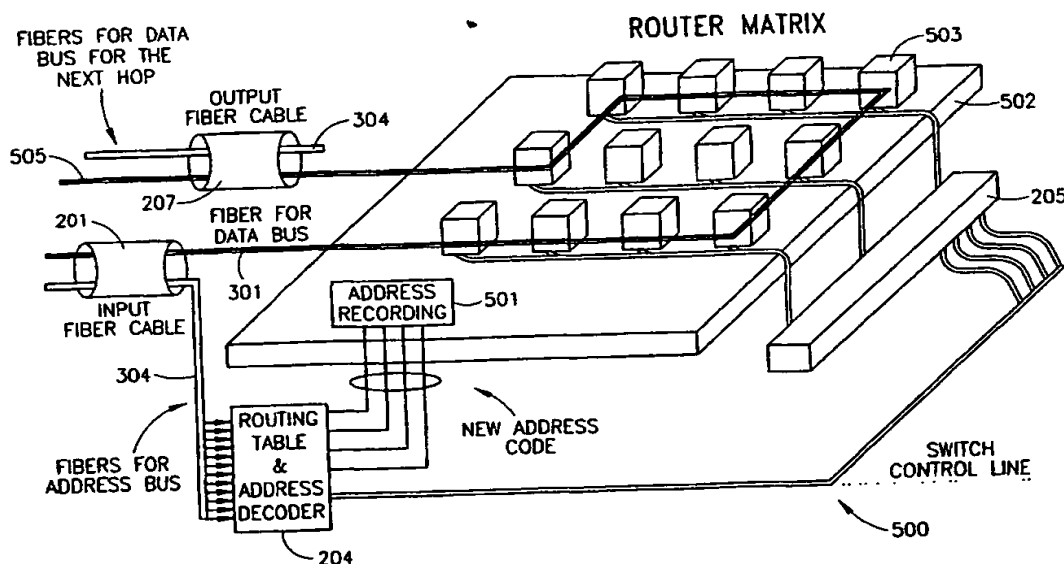
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ance Notes on Codes and Abbreviations" appearing at the begin-
ning of each regular issue of the PCT Gazette.

(54) Title: **METHOD AND APPARATUS FOR ROUTING DATA-CARRYING OPTICAL SIGNALS**



(57) Abstract: A method is provided for routing optical data, which method comprises transmitting optical addressing data to a first network element having routing capabilities, assigning an appropriate optical link connecting the first network element with a second network element where the assignment is based on the optical addressing data, and transmitting the optical data via the assigned optical link.

WO 01/56230 A2

METHOD AND APPARATUS FOR ROUTING DATA-CARRYING OPTICAL SIGNALS

Field of the Invention

5 The present invention relates to the field of data packet switching. More particularly, the invention relates to a method and apparatus for routing high speed optical data by using a control header which comprises an optical routing address that is transmitted optically.

Background of the Invention

Many modern communication networks employ optical transmission of data packets. The main advantage of optical transmission is almost unlimited bandwidth, which allows transmitting data at high rates. Data is divided into packets, each of which containing information that should be delivered to a destination, and a header that contains the routing data. The routing data comprises address information which is used to route the data through a series of switching nodes to its destination. Each switching node decodes the address information by processing the header information and switching the packet onto a proper communication link (usually using a routing table that is stored in each switching node). The same procedure is repeated at the next node and so forth, until the packet reaches its destination.

Conventional routing methods of data packets in optical networks employ electrical processing of the header information, which is carried out at each switching node. However, due to hardware limitations such electrical processing is performed in a relatively low rate, and therefore the "decision" made at each switching node, through which communication link to forward each packet is delayed. Therefore, the overall delay time of each delivered packet from source to destination is increased.

US Patent 5,253,250 discloses an apparatus for switching of high speed optical data with the header information transmitted separately on a sub-carrier frequency. The header information is sub-carrier multiplexed with the data packet and is then transmitted at a lower rate than the information frame rate, so as to allow header processing by less expensive receivers. However, the data packet is delayed by an optical buffer for the time required for the switch to process the header information.

European Patent Application EP 794683A2 discloses an optical ATM self-routing switching system with reduced routing header bits. The switching system comprises a plurality of interface means responsive to an incoming ATM cell for producing an optical ATM cell containing a routing bit located in a time slot corresponding to the its destination. This allows to reduce the optical header bits and improve the data throughput. However, the remaining bits in the header are still electrically processed and therefore the routing of the optical information data is delayed.

US Patent 5,912,753 discloses an optical network in which a packet is routed by performing a logic operation between an address word carried in its header and a predetermined discriminator word. A routing decision is made according to the result of the logic operation. However, the logic operation is performed by electrically processing and therefore the routing of the optical information data is delayed.

US Patent 5,617,233 discloses a transparent optical node (TON) structure for use in optical packet switching architecture. Routing is performed by using a separate wavelength to carry the header information. The header portion of the packet is removed from the data portion and can be rewritten before reinsertion.

Still, even only the header portion requires processing time to determine the desired routing decision, and therefore delays the packet routing.

US Patent 5,982,516 discloses an optical network in which data signals are encoded with a wavelength that corresponds to the destination address, so that data is routed in accordance with which of the switch characteristic wavelengths, matches the data encoding wavelength.

All the methods described above have not yet provided satisfactory solutions to the problem of providing method and apparatus for routing high speed optical data by using an optical routing address.

It is therefore an object of the present invention to provide a method and apparatus for routing high speed optical data, which overcome the drawbacks of prior art.

It is another object of the present invention to provide a method and apparatus for routing high speed optical data by using a control header which comprises an optical routing address that is transmitted optically.

It is another object of the present invention to provide a method and apparatus for routing high speed optical data by using an optical routing address which requires simple electrical processing.

Other objects and advantages of the invention will become apparent as the description proceeds.

Summary of the Invention

The present invention is directed to a method for routing optical data. By a first embodiment of the invention, the method provided comprises transmitting optical addressing data to a network element having routing capabilities, assigning an appropriate optical link in the network element where the assignment is based on the addressing data, and transmitting the optical data via the optical link thus assigned. The network element in accordance with the present invention is a device provided with routing capabilities, e.g. a router, and the like. For the sake of convenience such a network element will be referred to hereinafter as a "router", but this term should be understood to encompass also any other device having switching and forwarding capabilities. The addressing information required for establishing such an address for routing the optical data signals is derived from a combination of the optical addressing signals. By an embodiment of the invention, first optical addressing signals are generated by converting signals identifying a destination address into corresponding optical addressing signals. The optical addressing signals are transmitted over one or more optical addressing links to a first router and the optical data signals are concurrently or subsequently transmitted to the first router via an optical data link. Preferably, second optical addressing signals are generated, defining the next section of a transmission path extending from the first router towards the destination address. The second optical addressing signals are then transmitted over one or more optical addressing links extending between the first router and a second router. The optical data signals are concurrently or subsequently transmitted to the second router via an optical data link extending between the first router and the second router. The process is repeated until the optical data signals are transmitted to the destination address via subsequent routers located along a transmission path extending towards the destination address.

The information may be extracted from at least one of the optical addressing signals transmitted at one of two binary illumination states. At least one of the optical addressing signals may be transmitted at a certain illumination level whereas at least one other optical addressing signal is presented by absence of illumination.

According to another embodiment of the invention, at least two of the optical addressing signals may be transmitted each at substantially the same wavelength and at a different illumination intensity and wherein each of the illumination intensities corresponds to a different addressing information. Alternatively, at least two of the optical addressing signals may be transmitted each at substantially the same intensity and at a different wavelength, and wherein each of the different wavelengths corresponds to a different addressing information.

An optical address may be derived from a combination of at least two optical addressing signals each transmitted at a different wavelength and/or at a different intensity from the other.

According to a preferred embodiment of the invention, the transmission of at least one of the optical data signals is delayed until the following steps are performed:

- a) decoding the optical addressing signals;
- b) deriving addressing information from the decoded optical addressing signals; and
- c) if required, generating another, or using the, optical routing address for further routing of the optical data signals.

The transmission of the at least one of the optical data signals may be delayed by allowing the at least one of the optical data signals to pass through an optic fiber of a length corresponding to a desired delay in the transmission.

- 5 In accordance with yet another preferred embodiment of the invention, optical data signals are routed by:
- a) generating first optical addressing signals by converting the signals identifying a destination address into corresponding optical addressing signals;
 - b) assigning optical addressing links towards the destination address;
 - 10 c) establishing a data transmission path between a transmission source transmitting the optical addressing signals over one or more and a destination for the transmission of the optical data signals;
 - d) transmitting an indication that the optical data signals can be forwarded towards their destination;
 - 15 e) receiving the indication; and
 - f) transmitting the optical data signals towards the destination along the data transmission path.

The indication may be an optical indication signal, transmitted to the
20 transmission source via the data transmission path, an electric indication signal, and the like.

The invention is also directed to an apparatus for transmitting optical data signals using one or more optical addressing links for carrying optical
25 addressing signals, the combination of which provides addressing information required for establishing an address for routing the optical data signals that are transmitted via an optical data link.

By still another embodiment of the invention, the apparatus comprises:

a) means for generating first optical addressing signals by converting signals identifying a destination address into corresponding optical addressing signals;

5 b) means for transmitting the optical addressing signals over one or more optical addressing links to a first router; and

c) means for transmitting the optical data signals to the first router via an optical data link.

10 According to another embodiment of the invention there is provided an apparatus that comprises:

a) means for receiving first optical addressing signals;

b) means for generating second optical addressing signals associated with the next section of a transmission path extending towards the destination address;

15 c) means for transmitting the second optical addressing signals over one or more optical addressing links extending towards the destination address ;

d) means for receiving the optical data signals; and

e) means for transmitting the optical data signals received towards the destination address.

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According to a preferred embodiment of the invention, the apparatus comprises:

a) means for delaying optical data signals;

b) means for decoding the optical addressing data;

25 c) means for deriving addressing information from the decoded optical addressing signals; and

d) means for generating optical routing address for further routing of optical data signals.

An optic fiber may be included for delaying the transmission of at least one of the optical data signals and means for directing the at least one of the optical data signals to pass through the optic fiber.

5 According to still a further embodiment of the invention there is provided an apparatus that comprises:

- a) means for receiving optical addressing signals;
- b) circuitry for converting received optical addressing signals into routing signals;
- 10 c) a memory for storing predetermined and/or updated routing signals;
- d) circuitry for comparing the routing signals with stored electrically represented addressing data stored in the memory;
- e) means for generating optical addressing signals corresponding to said optical data signals' destination address;
- 15 f) means for transmitting said optical addressing signals over one or more optical addressing links towards said destination address; and
- g) circuitry for directing the incoming optical data signals to the corresponding outgoing optical data link by controlling the optical connection between incoming and outgoing optical paths according to the results of the
- 20 comparison.

By another aspect of the present invention, there is provided a system comprising :

- a) at least one data source for sending optical data signals to a
- 25 destination over an optical data link;
- b) at least one destination for receiving optical data signals sent from the source over the optical data link; and
- c) at least one optical router for routing optical data signals transmitted from the data source towards the destination, according to optical

addressing data transmitted to the optical router before assigning an appropriate optical link in the optical router by using the addressing data.

5 In accordance with an embodiment of the invention, the telecommunication system provided comprises:

- a) means for generating first optical addressing signals by converting the signals identifying a destination address into corresponding optical addressing signals;
- 10 b) means for transmitting the optical addressing signals over one or more optical addressing links towards the destination address;
- c) a data transmission path extending between a transmission source and a destination for the transmission of the optical data signals;
- d) means for transmitting to the transmission source an indication that the
- 15 optical data signals can be forwarded towards their destination; e) means for receiving the indication; and
- f) means for transmitting the optical data signals responsive to receiving said indication, towards the destination along the data transmission path.

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Preferably, the telecommunication system comprises one or more optical addressing links for carrying a combination of optical addressing signals to the router, the combination provides addressing information required for establishing an address for routing the optical data signals.

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By using the term optical data signals, it is meant to include data-carrying optical signals, out-band optical signals, message's optical signals, indication optical signals, addressing optical signals and the like. By using the term routing signals, it is meant to include any type of signals (e.g., electrical digital

or analogue signals) that can be extracted from the received optical address and used for controlling optical routing hardware according to the received addressing information.

5 **Brief Description of the Drawings**

The above and other characteristics and advantages of the invention will be better understood through the following illustrative and non-limiting detailed description of preferred embodiments thereof, with reference to the appended drawings, wherein:

- 10 - Fig. 1 schematically illustrates the structure of a conventional optical data network;
- Fig. 2 schematically illustrates the structure of a routing system of data carrying light beam used in an optical router, according to a preferred embodiment of the invention;
- 15 - Fig. 3 schematically illustrates the generation of an optical address, according to a preferred embodiment of the invention;
- Fig. 4 schematically illustrates the decoding of an optical address, according to a preferred embodiment of the invention; and
- Fig. 5 schematically illustrates the structure of a router with optical
20 addressing system, according to a preferred embodiment of the invention.

Detailed Description of Preferred Embodiments

- Fig. 1 schematically illustrates the structure of a conventional optical data network. The system 100 comprises a plurality of routers 101a to 101e, each of
25 which is used to direct data carried from a source to a destination by way of an optical signal routed through several routers that are connected by a set of optical links 102a to 102i, such as optic fibers. For example, data from source S intended to destination D1 can be directed to its destination by routers 101a and 101b through links 102a, 102b and 102d, or alternatively by routers 101a 101c

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and 101b through links 102a, 102c, 102i and 102d. Each router comprises a routing table which determines to which router and through which link the data will be forwarded at each step, until the last router opens (or switches) the corresponding link to the destination. These routing tables are periodically updated according to varied traffic loads and network availability. IP routing procedure as known in the art *per se* is an example of a procedure where such a periodic update is carried out. Each router comprises an array (a "router matrix") of controlled optical switches that are activated according to the destination address and to the updated routing tables. Conventional optical switching schemes employ electrical processing of each data packet by reading the header information and extracting the destination address of that packet. The extracted address is presented to the routing table of each router and in response the router selects the next router and a corresponding optical link, through which the optical (data carrying) signal will be forwarded so as to proceed to its proper destination. In addition, the router may also convert the extracted address to another address which represents the destination in the routing table of the next router (i.e., each router may have different address code for the same destination). Typically, the switching operation is carried out by deflecting the light beam using a device such as electrically controlled prisms, mirrors, liquid crystals and the like.

Contrary to prior art routing scheme, a preferred embodiment of the present invention is schematically illustrated in Fig. 2, wherein the structure of a routing system of data carrying light beam used in an optical router, is illustrated. The system 200 comprises an optical link 201 which comprises an optical data bus 202 and an optical address bus 203. The optical data bus 202 may consist of an optic fiber which is connected between the router and the data source S and/or its neighboring routers. The optical address bus 203 consists of a bundle of optic fibers which together form the routing address by an optical

image. For example, if the bundle comprises eight fibers, each fiber may represent at least two logical states, in case when a binary address is used. The first logic level may emulate a "1" logic by illuminating the fiber with laser radiation (light) emitted from a laser diode and the second logic level may emulate a "0" logic by deactivating the laser diode (no light in the fiber). This binary combination allows to obtain up to $256=2^8$ different routing addresses. The optical image thus received is detected by an array of electro-optical address detectors 204 by using a plurality of photo-sensitive elements (e.g., a photodiode) each located at the end of each fiber. Each of the photo-sensitive elements detects the emitted light and outputs a corresponding electric signal which is converted to a logic level. The combination of all logic levels of each fiber in the bundle forms the routing address. The routing address is compared with the contents of the routing table of the router and the comparison result is used to generate a control signal. The generated control signal is fed into a controller 205 which outputs a corresponding voltage to each optical switch within the router. In response, the array of optical switches contained in the router matrix 206 is controlled so that the desired optical switch routes (deflects) the data carrying light arriving into the router through the optical data bus 202 (from the source or from the preceding router), to the selected optical link that connect the current router to the next router. In parallel, a new optical address is generated using the address data which is stored in the routing table and the destination, so as to deliver a new addressing data to the next router.

The new optical address is generated by an array of light emitting sources such as laser diodes, Light Emitting Diodes (LEDs) and the like, each of which is attached to an optic fiber within the bundle that leads to the next router. The resulting new optical address is carried by a new bundle of optic fibers 208, which in parallel with the data bus of the next optical link 207, is directed to the next router. The next router decodes it and uses the (decoded) extracted address

to route the arriving optical data to another router. This process continues from each router to the next router, while each router controls its optical switches to direct an incoming data carrying light beam according to the destination and the current contents of its routing table, until data carrying light beam can reach the last router. Finally the last router allows the optical link to reach the destination.

From that point the complete optical link (i.e., optical connection between source and destination) is open for data transmission from the data source to its destination, via the corresponding routers and optical links. According to a preferred embodiment of the invention, after opening the complete optical link for data transmission, an optical indication signal is transmitted from the last router via the opened link back to the source. This indication signals the data source that the complete optical link is open and enables the source to start transmitting data. Once the link is open, relatively large amount of data can be transmitted over the link to the destination. The indication signal may be for example light of a specific wavelength, which may even be visible, such as "coloring" the complete opened channel with red light. Of course, other signaling techniques may be implemented. The optical indication signal is detected at the source (e.g., by a photo-sensitive element) and enables data transmission. Since the signaling and routing addresses are delivered optically, the operations required to establish the link may be carried out relatively fast (essentially at light velocity). Therefore, the remaining electrical operations (optical address decoding/encoding and controlling the optical switches) are simplified and the whole transmission process is carried out rapidly.

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Of course, more addresses can be obtained according to another preferred embodiment of the invention, by using more options than the "ON/OFF" type of method described above. Such options may further comprise different illumination levels in each fiber and/or different wavelengths in each fiber (e.g.,

different colors of laser light) or any combination thereof, which substantially increase the number of addresses that can be obtained using a given number of fibers in a bundle. Alternatively, using such options may decrease the number of fibers required in a bundle for a given number of addresses.

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Fig. 3 schematically illustrates the generation of an optical address, according to a preferred embodiment of the invention. The optical link 301 comprises a laser diode 300 at its distal end, which emits light that is modulated by the data that should be transmitted. The modulated light is radiated to an optic fiber 301. An array of N light emitting sources 302, such as laser diodes is controlled to generate a combination of lighted/unlighted pixels, each of which corresponds to a specific light emitting source. The light of each pixel is radiated into a corresponding optic fiber 303 and represents an element of the desired routing address. The optical link 301 also comprises the resulting bundle 304 of N optic fibers, which represents the optical address bus. The fibers in bundle 304 may be arranged in a way that the optic image received therefrom represents the optical address as a vector 305, or as an array 306 having any applicable geometrical arrangement. In this example, the dark points in the vector 305 (or array 306) represent a lit fiber that corresponds to "1" logic and the brighter points represent an obscure fiber that corresponds to "0" logic. Therefore, the optical address in this example represents the binary combination "1,0,1,1,0,0,1,0,1,1,1" (of 2^{11} possible combinations).

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Fig. 4 schematically illustrates the decoding of an optical address, according to a preferred embodiment of the invention. An array of N photo-sensitive components, such as photodiodes 401 are located at the end of each fiber 303 of the bundle (of N fibers) 304. Each photo-sensitive component receives the light emitted (if emitted) from its corresponding fiber and in response outputs a related electric signal which is then transformed into a corresponding logic

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level. The combination of N logic levels forms the desired address (of 2^N possible combinations in the case of "ON/OFF" keying method).

Fig. 5 schematically illustrates the structure of a router with optical addressing system, according to a preferred embodiment of the invention. The router 500 comprises a router matrix 502 consisting of a plurality of voltage controlled optical switches 503. Incoming optical data carrying signal is input to the router matrix 502 via the data fiber 301. The bundle 304 of address fibers are input into the electro-optical address detector 204 and the address is extracted from the light information carried by the bundle 304. The address is compared to the contents of the router's routing table and a set of resulting corresponding signals is input to the controller 205, which controls the optical switches 503 to open the desired optical path, so as to direct an incoming data carrying light beam to the output (next) optical cable 207. Cable 207 essentially comprises the address fibers' bundle 304, and data fiber 505. In addition, the resulting signals are input to an address generator 501, so as to generate a new optical address according to the current addressing information resulting from the combination of the routing table and the received optical address. The new optical address is transmitted via another bundle 304.

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According to another preferred embodiment of the invention, data packets can be transmitted from a router to the next router, by generating optical delay of the data carrying optical signal, so as to enable each router to decode the optical address and to allow the required optical link to the next router. Such delay may be obtained by using an optical link which is implemented by using a relatively long optic fiber. A longer fiber provides longer delay time. By doing so, packets can be transmitted via the optical link without waiting until the complete optical link is established. In addition, optical signaling from the last router back to the source, indicating that the link is established is not required. Data packets are

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transmitted from the source to the first router over the data fiber (which is sufficiently long to delay the optical data), in parallel with their corresponding optical address which is optically transmitted over the address fibers' bundle. The router decodes the optical address and allows the corresponding link to the next router, according to its routing table. The delay time is determined so that the delayed optical data reaches the router after the corresponding link to the next router is already established and the next address is generated, and proceeds to the next router over another data fiber, which again delays the optical data, until the next router opens the next corresponding link. This process may be continued, until the optical data reaches the last router.

Furthermore, such an arrangement for inducing delays in the transmission of optical data may also include devices such as amplifiers, receive/transmit units or any other applicable devices that are adapted to compensate for the signal degradation that may occur when long delay fibers are incorporated in the data transmission path.

The above examples and description have of course been provided only for the purpose of illustration, and are not intended to limit the invention in any way. As will be appreciated by the skilled person, the invention can be carried out in a great variety of ways, employing more than one technique from those described above, all without exceeding the scope of the invention.

CLAIMS

1. A method for routing optical data comprising the steps of:
transmitting optical addressing data to a first network element having routing
5 capabilities;
assigning an appropriate optical link connecting said first network element with
a second network element where the assignment is based on the optical
addressing data; and
transmitting the optical data via the assigned optical link.

10

2. In a telecommunication system, a method for routing optical data signals
using one or more optical addressing links for carrying optical addressing
signals, wherein a combination of said optical addressing signals provides
addressing information required for establishing an address for routing the
15 optical data signals and wherein said optical data signals are transmitted via an
optical data link.

3. In a telecommunication system, a method for routing optical data signals,
which method comprises:

- 20 a) generating first optical addressing signals by converting signals identifying a
destination address into corresponding optical addressing signals;
b) transmitting said optical addressing signals over one or more optical
addressing links to a first router; and
c) concurrently or subsequently, transmitting said optical data signals to said
25 first router via an optical data link.

4. A method according to claim 3, further comprising the steps of:

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- d) generating second optical addressing signals associated with the next section of a transmission path extending from said first router towards said destination address;
- e) transmitting the second optical addressing signals over one or more optical addressing links extending between said first router and a second router;
- f) concurrently or subsequently, transmitting said optical data signals to said second router via an optical data link extending between said first router and said second router; and
- g) repeating steps (d) to (f) until said optical data signals are transmitted to said destination address via subsequent routers located along a transmission path extending towards said destination address.

5. A method according to any one of the preceding claims, wherein at least one of the optical addressing links and/or the optical data link is an optic fiber.

6. A method according to any one of claims 2 to 4, wherein the information extracted from at least one of the optical addressing signals transmitted at one of two binary illumination states.

7. A method according to any one of claims 2 to 4, wherein at least one of the optical addressing signals is transmitted at a certain illumination level whereas at least one other optical addressing signal is presented by absence of illumination.

8. A method according to any one of claims 2 to 4, wherein at least two of the optical addressing signals are transmitted each at substantially the same wavelength and at a different illumination intensity and wherein each of the illumination intensities corresponds to a different addressing information.

9. A method according to any one of claims 2 to 4, wherein at least two of the optical addressing signals are transmitted each at substantially the same intensity and at a different wavelength, and wherein each of the different wavelengths corresponds to a different addressing information.

5

10. A method according to any one of claim 6 to 8, wherein an optical address is derived from a combination of at least two optical addressing signals each transmitted at a different wavelength and at a different intensity from the other.

10

11. A method according to any one of the preceding claims, wherein the transmission of at least one of the optical data signals is delayed until the following steps are performed:

- a) decoding said optical addressing signals;
- 15 b) deriving addressing information from the decoded optical addressing signals; and
- c) if required, generating another, or using said, optical routing address for further routing of said optical data signals.

20 12. A method according to claim 11, wherein the transmission of said at least one of the optical data signals is delayed by allowing said at least one of the optical data signals to pass through an optic fiber of a length corresponding to a desired delay in the transmission.

25 13. In a telecommunication system, a method for routing optical data signals, which method comprises:

- a) generating first optical addressing signals by converting the signals identifying a destination address into corresponding optical addressing signals;

- b) assigning optical addressing links towards said destination address;
- c) establishing a data transmission path between a transmission source transmitting said optical addressing signals over one or more and a destination for the transmission of the optical data signals;
- 5 d) transmitting to said transmission source an indication that said optical data signals can be forwarded towards their destination;
- e) receiving said indication at said transmission source; and
- f) transmitting said optical data signals towards said destination along said data transmission path.

10

14. A method according to claim 13, wherein step (f) is delayed until step (e) is completed.

15

15. A method according to claim 13, wherein the indication is an optical indication signal.

16. A method according to claim 15, wherein the optical indication signal is transmitted to the transmission source via the data transmission path.

20

17. A method according to claim 15, wherein the indication is an electric indication signal.

25

18. Apparatus for routing optical data signals using one or more optical addressing links for carrying optical addressing signals, the combination of which provides addressing information required for establishing an address for routing the optical data signals that are transmitted via an optical data link.

19. Apparatus for routing optical data signals, said apparatus comprises:

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- a) means for generating first optical addressing signals by converting signals identifying a destination address into corresponding optical addressing signals;
- b) means for transmitting said optical addressing signals over one or more optical addressing links to a first router; and
- c) means for transmitting said optical data signals to said first router via an optical data link.

20. Apparatus according to any one of claims 18 to 19, comprising at least one of the optical addressing links and/or the optical data link which is an optic fiber.

21. Apparatus according to any one of claims 18 to 20, in which at least one of the optical addressing signals is transmitted by using one of two binary illumination states.

22. Apparatus according to one of claims 18 to 20, in which at least one of the optical addressing signal is transmitted at a certain illumination level and at least another optical addressing signal is presented by absence of illumination.

23. Apparatus according to any one of claims 18 to 20, in which at least two of the optical addressing signals are transmitted at substantially similar wavelength and at a different illumination intensity, and each of the illumination intensities corresponds to a different addressing information.

24. Apparatus to any one of claims 18 to 20, wherein at least two of the optical addressing signals are transmitted at a different wavelength, and each of the different wavelengths corresponds to a different addressing information.

25. Apparatus according to Claim 24, wherein said at least two of the optical addressing signals are transmitted at substantially similar intensity.

26. Apparatus according to any one of claim 18 to 20, in which at least two
5 of the optical addressing signals are transmitted each at a wavelength and intensity that are different from the wavelength and intensity of the other one of said at least two of the optical addressing signals.

27. Apparatus according to any one of claims 18 to 26, further comprising:

- 10 a) means for delaying optical data signals;
b) means for decoding said optical addressing data;
c) means for deriving addressing information from the decoded optical addressing signals; and
d) means for generating optical routing address for further routing of optical
15 data signals.

28. Apparatus according to claim 27, comprising an optic fiber for delaying the transmission of at least one of the optical data signals and means for directing said at least one of the optical data signals to pass through said optic
20 fiber.

29. Apparatus for routing optical data signals, comprising:

- a) circuitry for converting received optical addressing signals into routing signals;
25 b) a memory for storing predetermined and/or updated routing signals;
c) circuitry for comparing the routing signals with addressing data stored in the memory; and

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d) circuitry for directing the incoming optical data signals to the corresponding outgoing optical data link by controlling the optical connection between incoming and outgoing optical paths according to the results of the comparison.

5 30. A telecommunication system comprising one or more optical addressing links for carrying a combination of optical addressing signals to the router, the combination provides addressing information required for establishing an address for routing the optical data signals.

10 31. A telecommunication system comprising:

a) means for generating first optical addressing signals by converting signals identifying a destination address into corresponding optical addressing signals;

b) means for transmitting said optical addressing signals over one or more optical addressing links towards said destination address;

15 c) a data transmission path extending between a transmission source and a destination for the transmission of the optical data signals;

d) means for transmitting to said transmission source an indication that said optical data signals can be forwarded towards their destination;

e) means for receiving said indication ; and

20 f) means for transmitting said optical data signals responsive to receiving said indication, towards said destination along said data transmission path.

32. A system according to claim 31, wherein the indication is an optical indication signal.

25

33. A system according to claim 32, in which the optical indication signal is transmitted to the transmission source via the data transmission path.

34. A system according to claim 31, in which the indication is an electric indication signal.

35. Apparatus for generating optical addressing signals for routing optical data signals adapted to be transmitted via an optical data link, comprising:

- a) one or more controllable light sources; and
- b) a control circuitry for causing each of said controllable light sources to emit light, of a wavelength and/or of illumination intensity, according to an electrical addressing signal that corresponds to a specific address element.

36. Apparatus according to claim 35, further comprising:

- c) one or more optical links, each of which is associated with said one or more controllable light sources, for optically transmitting one or more optical address signals in parallel with, or prior to, the routed optical data signals.

37. Apparatus for transmitting optical data signals, comprising:

- a) means for generating optical addressing signals by converting signals identifying a destination address into corresponding optical addressing signals;
- b) means for transmitting said optical addressing signals over one or more optical addressing links towards said destination address; and
- c) means for transmitting said optical data signals towards said destination.

38. An apparatus according to Claim 37, further comprising means for receiving an indication that said optical data signals can be forwarded towards their destination, wherein said means for transmitting said optical data signals is adapted to transmit the optical data signals towards said destination responsive to receiving said indication.

39. Apparatus for routing optical data signals, comprising:

- a) means for receiving optical addressing signals;
- b) circuitry for converting received optical addressing signals into routing signals;
- c) a memory for storing predetermined and/or updated routing signals;
- 5 d) circuitry for comparing the routing signals with addressing data stored in the memory; and
- e) means for generating optical addressing signals corresponding to said optical data signals' destination address;
- f) means for transmitting said optical addressing signals over one or more
- 10 optical addressing links towards said destination address; and
- g) circuitry for directing the incoming optical data signals to the corresponding outgoing optical data link by controlling the optical connection between incoming and outgoing optical paths according to the results of the comparison.

15 40. A telecommunication routing apparatus comprising:

- a) means for receiving first optical addressing signals;
- b) means for generating second optical addressing signals associated with the next section of a transmission path extending towards the destination address;
- c) means for transmitting the second optical addressing signals over one or
- 20 more optical addressing links extending towards the destination address ;
- d) means for receiving the optical data signals; and
- e) means for transmitting the optical data signals received towards the destination address.

25 41. A method for routing optical data signals according to optically transmitted addressing signals, substantially as described and illustrated.

42. Apparatus for routing optical data signals according to optically transmitted addressing signals, substantially as described and illustrated.

43. A telecommunication system comprising routing optical data signals according to optically transmitted addressing signals, substantially as described and illustrated.

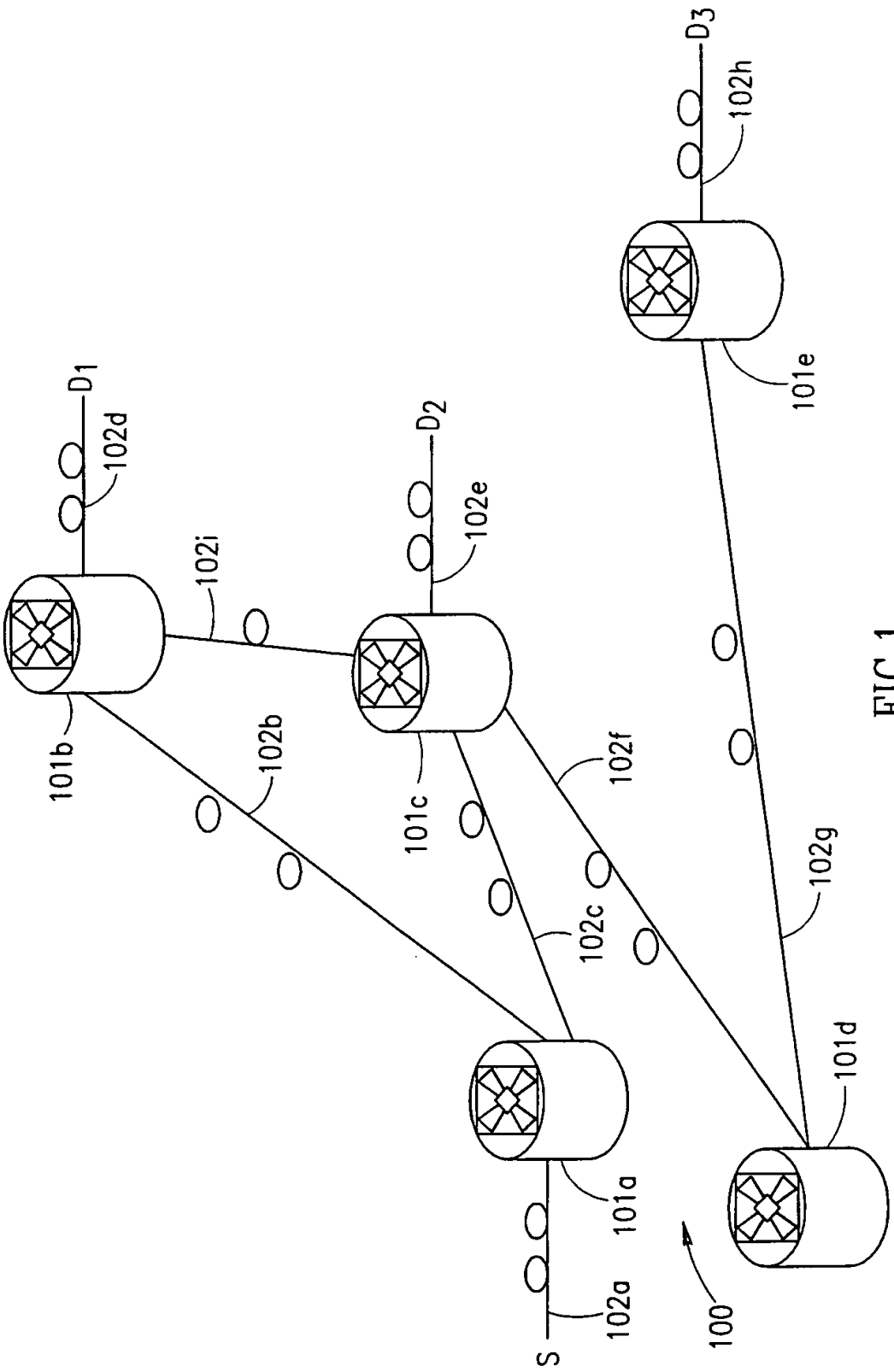


FIG.1
PRIOR ART

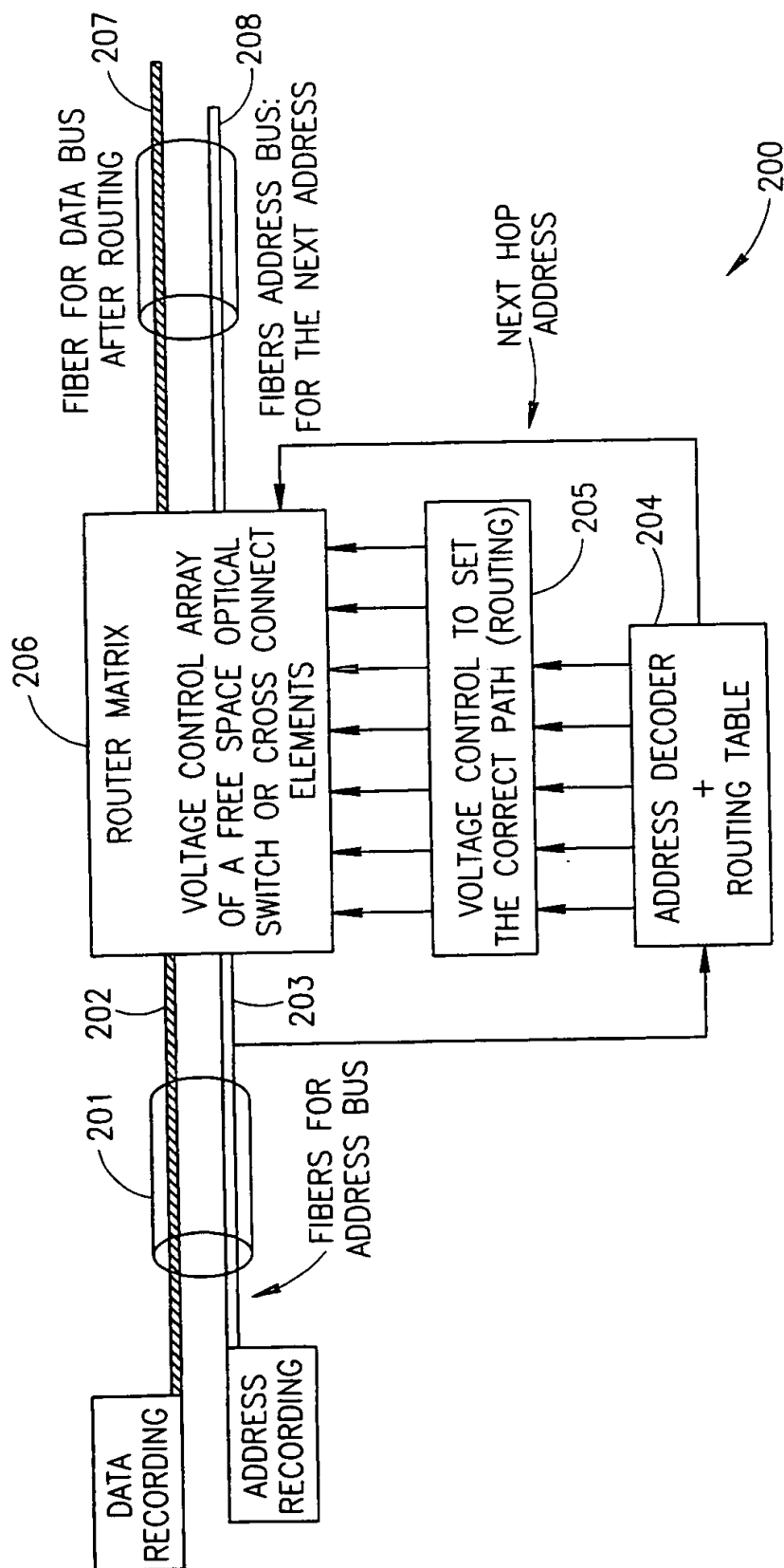


FIG. 2

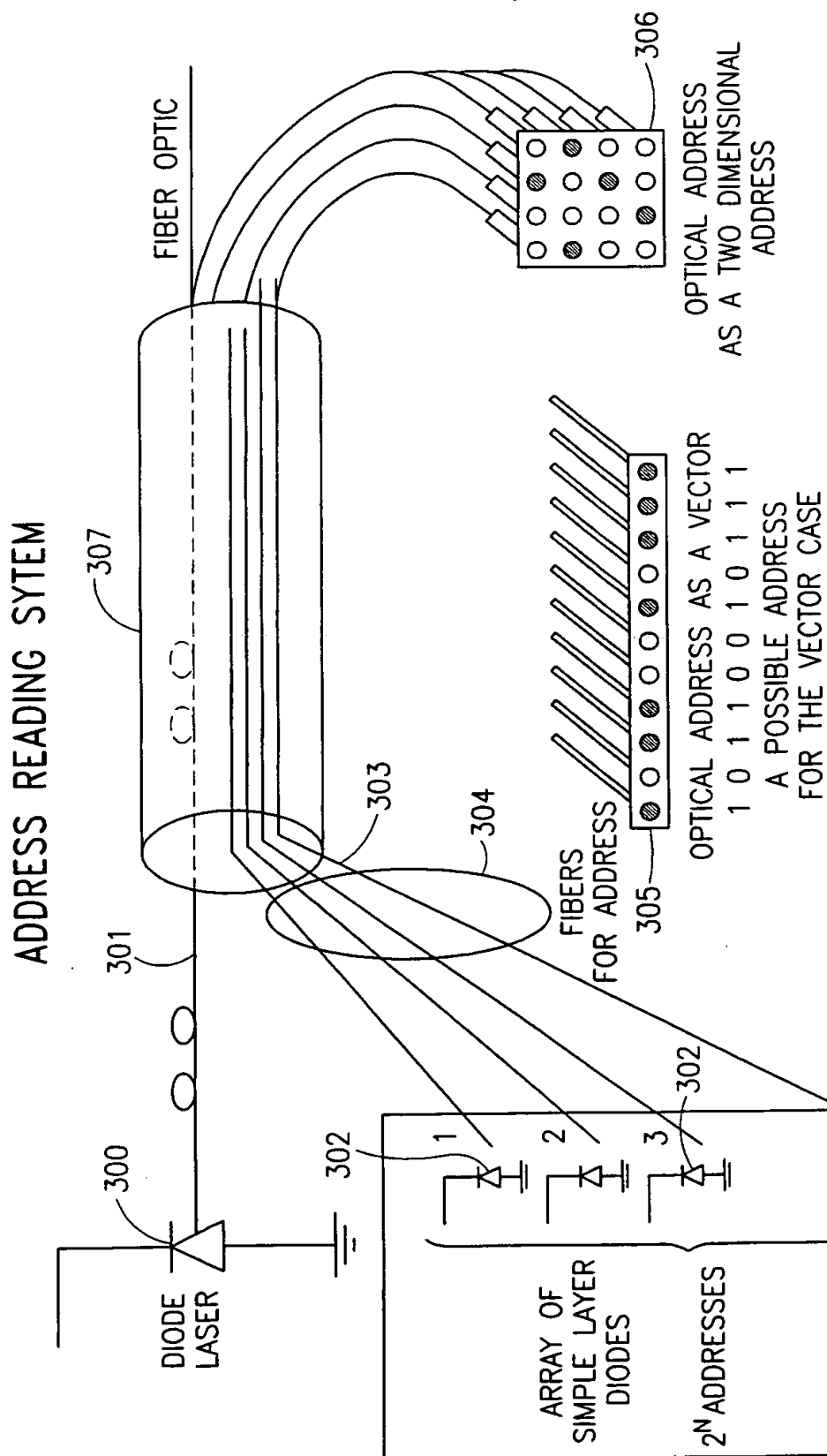
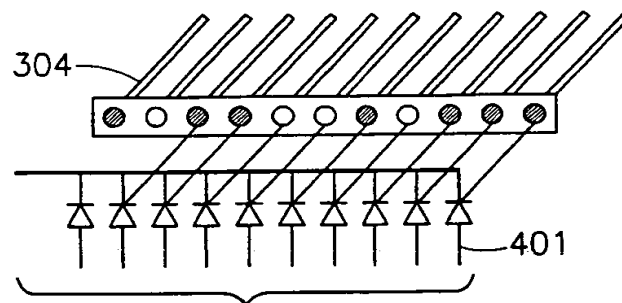


FIG. 3

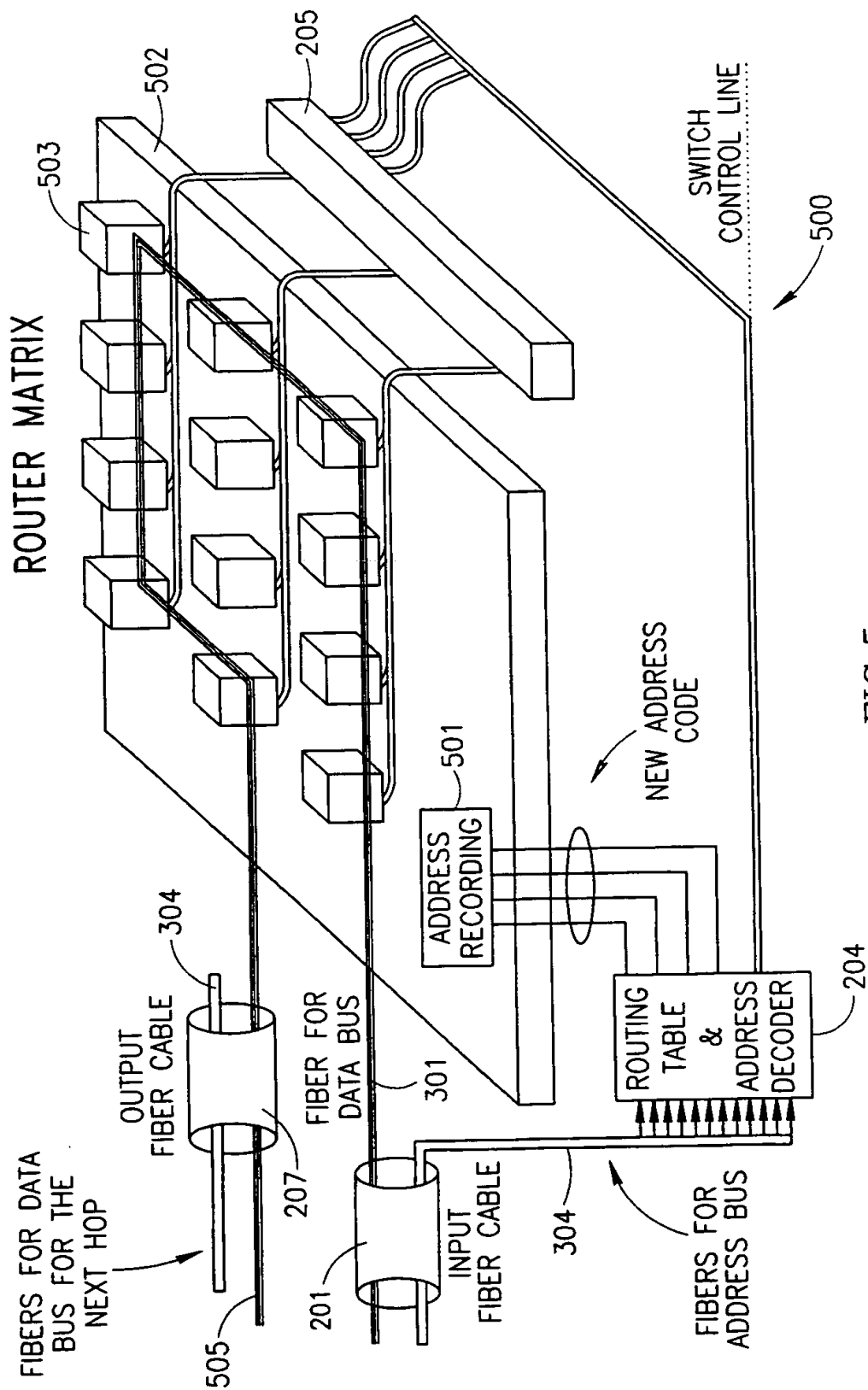
4/5



OUTPUT VECTOR TO
DECIDE THE ROUTER SWITCHING
POSITION AND DECIDE THE NEXT HOP
ADDRESS ACCORDING TO ITS ROUTING TABLE

FIG.4

5/5



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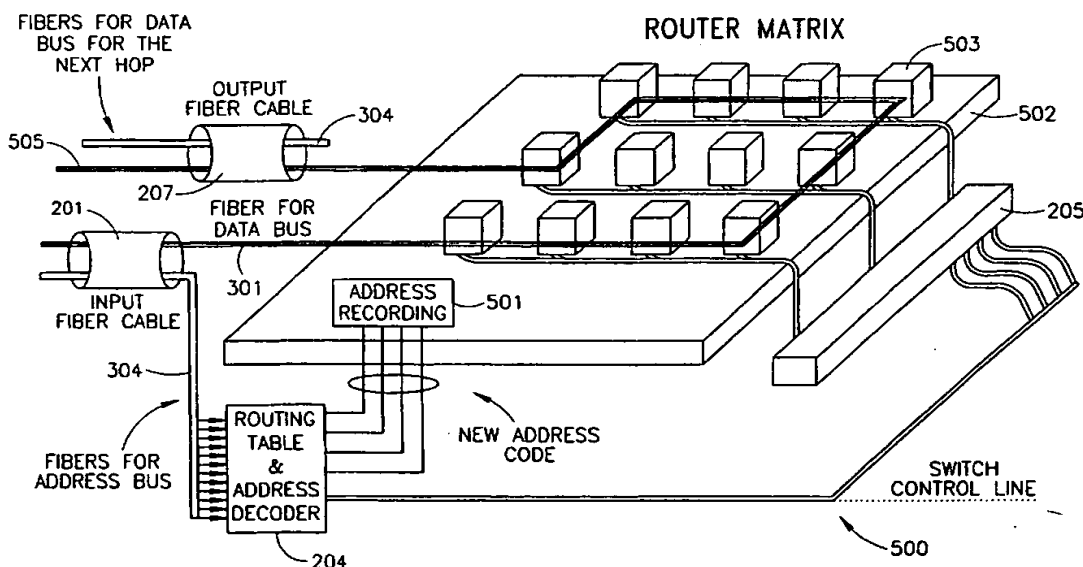
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(57) Abstract: A method is provided for routing optical data, which method comprises transmitting optical addressing data to a first network element having routing capabilities, assigning an appropriate optical link connecting the first network element with a second network element where the assignment is based on the optical addressing data, and transmitting the optical data via the assigned optical link.

INTERNATIONAL SEARCH REPORT

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Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 488 501 A (BARNSELY PETER E) 30 January 1996 (1996-01-30)	1-5, 11, 12, 18-20, 27-30, 35-43
A	figures 1,6,7	6-10, 13-17, 21-26, 31-34
A	US 5 541 756 A (CHANG-HASNAIN CONSTANCE J ET AL) 30 July 1996 (1996-07-30) figures 1-4	1-43

☒ Further documents are listed in the continuation of box C.

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	<p>JEONG G ET AL: "COMPARISON OF WAVELENGTH-INTERCHANGING AND WAVELENGTH-SELECTIVE CROSS-CONNECTS IN MULTIWAVELENGTH ALL-OPTICAL NETWORKS" PROCEEDINGS OF INFOCOM,US,LOS ALAMITOS, IEEE COMP. SOC. PRESS, vol. CONF. 15, 24 March 1996 (1996-03-24), pages 156-163, XP000622306 ISBN: 0-8186-7293-5 figure 3</p>	1-43
A	<p>HUI J Y: "PATTERN CODE MODULATION AND OPTICAL DECODING - A NOVEL CODE-DIVISION MULTIPLEXING TECHNIQUE FOR MULTIFIBER NETWORKS" IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS,US,IEEE INC. NEW YORK, vol. 3, no. 6, 1 November 1985 (1985-11-01), pages 916-927, XP000606948 ISSN: 0733-8716 figure 1</p>	1-43
A	<p>US 5 617 233 A (BONCEK RAYMOND K) 1 April 1997 (1997-04-01) cited in the application the whole document</p>	1-43
A	<p>US 5 253 250 A (EICHEN ELLIOT ET AL) 12 October 1993 (1993-10-12) cited in the application the whole document</p>	1-43

INTERNATIONAL SEARCH REPORT

Information on patent family members

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PCT/IL 01/00063

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 5488501	A	30-01-1996	AU 3901093 A CA 2123220 A,C DE 69323189 D DE 69323189 T EP 0635180 A ES 2127272 T WO 9321706 A SG 48849 A JP 7507188 T	18-11-1993 28-10-1993 04-03-1999 09-09-1999 25-01-1995 16-04-1999 28-10-1993 18-05-1998 03-08-1995
US 5541756	A	30-07-1996	NONE	
US 5617233	A	01-04-1997	NONE	
US 5253250	A	12-10-1993	CA 2085395 A EP 0550046 A JP 5268268 A	01-07-1993 07-07-1993 15-10-1993